EXHIBIT 3

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

SECURITIES AND EXCHANGE COMMISSION,

Plaintiff,

vs.

LEK SECURITIES CORPORATION,
SAMUEL LEK,
VALI MANAGEMENT PARTNERS dba AVALON FA LTD,
NATHAN FAYYER, and
SERGEY PUSTELNIK a/k/a SERGE PUSTELNIK,

Defendants.

Case No. 17-CV-1789

EXPERT REPORT OF NEIL D. PEARSON, PH.D.
MARCH 16, 2018

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List of Exhibits and Appendix

I. INTRODUCTION

A. Qualifications

1. My name is Neil D. Pearson. I am the Harry A. Brandt Distinguished Professor of Financial Markets and Options at the University of Illinois at Urbana-Champaign, where I teach courses on derivative financial instruments (including equity options) and the measurement of financial risks and conduct research on various issues in financial markets.[1] Before joining the University of Illinois I was on the faculty of the University of Rochester, in Rochester, NY. During one year I was on leave from the University of Rochester and served as a visiting academic in the Office of Economic Analysis at the U.S. Securities and Exchange Commission. At the SEC I worked on a policy proposal regarding the measurement and disclosure of financial risks, and I also assisted the Division of Enforcement with several investigations involving derivative financial instruments and financial fraud. During the 2008-2009 academic year I held an appointment as a Visiting Professor at the Massachusetts Institute of Technology, and during the fall of 2013 I was a Visiting Professor at the School of Economics and Management at Tsinghua University in Beijing.

2. I am on the editorial boards (Associate Editor) of the Journal of Financial Economics and the Journal of Financial and Quantitative Analysis, two of the leading academic finance journals. I am also on the editorial boards of the Journal of Risk, a specialty journal in risk management, and Economics Bulletin. I regularly act as a referee (reviewer) for other peer-reviewed academic journals in finance and economics.

[1] Derivative financial instruments, also referred to as financial derivatives, are financial instruments for which the cash flows or other payoffs are based on the prices of other financial instruments, foreign currencies, or commodities, or on interest rates quoted in financial markets. Equity call and put options, that is options giving the right to buy or sell stock at fixed prices, are examples of financial derivatives because their payoffs depend on future stock prices. I refer to these herein as equity options.

3. I have published more than 30 articles, book chapters, and other publications, and one book on risk measurement methodology. Some of these are mentioned in footnote 2 below.

4. I am affiliated with the risk management consultancy Rutter Associates of New York, NY. My consulting work through Rutter Associates focuses on the valuation and hedging of derivative financial instruments and on the measurement and management of market and credit risk. I have also worked on other consulting assignments, not through Rutter Associates, involving the valuation of derivative financial instruments and trading strategies that utilized such instruments.

5. Large parts of my teaching, research, and consulting involves equity options and other derivative financial instruments, including options trading and the interaction between the options markets and the options' underlying stocks. Throughout my academic career I have taught, and I continue to teach, courses on derivative financial instruments, including equity options. When I teach courses on financial derivatives one of the important topics that I cover is how some market participants legitimately trade in other financial instruments to hedge their exposure to the risk of changes in the values of their positions in financial derivatives. This includes teaching how options market makers trade in common stock to hedge the options positions that they acquire as part of their market-making activities. In my research, I have authored a number of papers that study either various aspects of the options markets and/or the interaction between the options and equity markets.[2] These include papers showing that

[2] For example, "Stock Price Clustering on Option Expiration Dates" (with Sophie Xiaoyan Ni and Allen Poteshman), Journal of Financial Economics 78, No. 1 (2005), 49-87; "Option Market Activity" (with Josef Lakonishok, Inmoo Lee, and Allen M. Poteshman), Review of Financial Studies 20, No. 3 (2007), pp. 813-857; "Is There Price Discovery in Equity Options" (with John P. Broussard and Dmitriy Muravyev), Journal of Financial Economics, Volume 107, No. 2 (2013), pp. 259-283; "Option Trading Costs Are Lower Than You

trading by options market makers in the underlying stocks to hedge their options positions impacts stock prices. In addition, most of my work with Rutter Associates, for various clients, has involved the valuation and/or hedging of derivative financial instruments, and I have also worked with an options market making firm on one of its proprietary trading strategies.

6. I earned a B.A. in Economics, summa cum laude, from Princeton University in 1981, and a Ph.D. in Management (specializing in Finance) from the Massachusetts Institute of Technology in 1990.

7. My publications during the most recent 10 years are listed on my curriculum vitae, a copy of which is attached as Exhibit 1. My curriculum vitae also describes my qualifications in more detail. My previous activities as an expert witness are listed in Exhibit 2.

Exhibit 1. *Curriculum Vitae of Neil D. Pearson, Ph.D.*

Exhibit 2. *Previous Expert Testimony of Neil D. Pearson, Ph.D.*

B. Materials Considered

8. The facts and data that I considered in forming the opinions expressed in this report are listed in Exhibit 3.

Exhibit 3. *Facts and Data Considered*

9. My opinions are also based upon my own educational and professional experience and background, including that listed in my curriculum vitae.

Think" (with Dmitriy Muravyev), Working Paper (2017); and "Does Option Trading Have a Pervasive Impact on Underlying Stock Prices?" (with Sophie Xiaoyan Ni, Allen M. Poteshman and Joshua White), Working Paper (2016).

C. Summary Of Assignment

10. My assignment involves consideration of a trading strategy that I refer to in this report as the "Cross-Market Strategy."[3] This or similar strategies have also been referred to as "mini-manipulation" and "Cross-Market, Cross-Product Manipulation."[4] Under the Cross-Market Strategy described more completely in Section II.B below, traders buy or sell stock for the purpose of artificially impacting the prices of the stock and related options, which price impacts typically cause the trader's options trades to be profitable or increase the profitability of the options trades. Because the Cross-Market Strategy involves purposely creating artificial prices, I consider the strategy to be manipulative.

11. The SEC asked me to review two sets of data reflecting orders, cancellations, and executions in the stock and the corresponding options of various companies. The first dataset ("Avalon Equity and Option Data") reflects transactions by Avalon FA Ltd. ("Avalon") through Lek Securities Corporation ("Lek") during the period of November 2010 through September 2016. The second dataset ("Lime Equity and Option Data") reflects transactions by traders through Lime Brokerage ("Lime") during the period of April 1, 2013 to April 12, 2013.[5] At times, I refer to the data collectively as the "Equity and Option Data." The SEC staff asked me to analyze the Equity and Option Data and form opinions as to:

a. Whether the Avalon Equity and Option Data revealed equity and options trading[6] (through Lek) consistent with the Cross-Market Strategy, and if so,

[3] This term, as well as "cross-market manipulation," and "cross-market scheme" is used by the SEC in its complaint to describe this strategy. See *Securities and Exchange Commission v. Lek Securities Corporation, et al.*, No. 17-CV-1789, Complaint, ¶3.

[4] See, for example, FINRA Regulatory and Examination Priority Letters for 2013-2016.

[5] For convenience, I will refer to trading by Avalon, Avalon traders, or Avalon trade groups as trading by Avalon.

[6] Here, and elsewhere in this report, "trading" refers to both executed and unexecuted orders.

to identify such trading;

b. Whether the Lime Equity and Option Data revealed equity and options trading (through Lime) consistent with the Cross-Market Strategy, and if so, to identify such trading; and

c. The amount of trading revenue, if any, attributable to the trading identified as consistent with the Cross-Market Strategy.

12. To do this, I directed a forensic examination and analysis of the Equity and Option Data, among other things.

13. I also have been asked to offer my opinions on whether the Cross-Market Strategy is manipulative and deceptive, whether it appears to have any legitimate economic rationale, and whether it is harmful to the securities markets and market participants.

14. I am independent of the SEC in this matter. My consulting rate is $600 per hour. My fees in this engagement are not in any way dependent on or contingent upon my findings or the outcome of this matter.

D. Summary Of Opinions

15. A summary of my opinions is as follows:

a. The Avalon Equity and Option Data reveals there are 636 instances in which Avalon's trading in stock and corresponding options (through Lek) is consistent with the Cross-Market Strategy;

b. These instances of the Cross-Market Strategy by Avalon (through Lek) garnered trading revenue of $7,703,166;

c. The Lime Equity and Option Data reveals 32 instances in which trading in stock and corresponding options (through Lime) is consistent with the Cross-

Market Strategy;

d. These instances of the Cross-Market Strategy executed through Lime garnered trading revenue of $450,799;

e. There does not appear to be any legitimate economic rationale for the trading activity that I identify as consistent with the Cross-Market Strategy; and

f. The Cross-Market Strategy is manipulative and deceptive, and harmful to the securities markets and market participants.

II. BACKGROUND

A. U.S. Equity Options Markets

16. Two kinds of equity options trade on the U.S. options exchanges: call and put options. A call option gives the holder the right to buy the underlying stock at a fixed price, called the strike price, on or before a specified date, termed the expiration date, while a put option gives the holder the right to sell the underlying stock in exchange for the strike price on or before the expiration date. Buying or selling the stock in exchange for the strike price is referred to as exercising the option. A call option will ordinarily only be exercised if the stock price exceeds the strike price, in which case the per-share exercise value or payoff is the difference between the stock price and the strike price.[7] A put option will ordinarily only be exercised if the stock price is less than the strike price, in which case the per-share exercise value or payoff is the difference between the strike price and the stock price. An option contract typically gives the holder the right to buy or sell 100 shares of stock, so that the

[7] In mathematical symbols, the per-share exercise value of a call is $S_T - K$, where S_T is the stock price on the exercise date and K is the strike price. This reflects the fact that the option holder who exercises a call option on date T receives the stock with price S_T and pays the strike price K. For a put the per-share exercise value is $K - S_T$, reflecting the fact that the option holder who exercises a put option on date T receives the strike price K and delivers the stock with price S_T.

exercise value or payoff of one contract is typically 100 times the per-share exercise value.

17. When options are trading (that is, prior to their exercise or expiration), their prices are related to stock prices because expected future stock prices, and thus option payoffs, are related to current stock prices. In particular, the prices of calls rise and fall with the underlying stock price, while the prices of puts move in the opposite direction from the underlying stock price.

18. U.S. equity options trade on a number of different options exchanges.[8] For each underlying stock and trade date there are typically a large number of options that differ in terms of their expiration dates and strike prices available for trading. For example, as of March 14, 2018 there were 1,020 different options contracts (510 calls and 510 puts) on VMware, Inc. (ticker symbol VMW) available for trading on the CBOE. These options had 11 different expiration dates ranging from March 16, 2018 to January 17, 2020, and strike prices between \$37.5 and \$230 per share.[9] VMW options were also available for trading on other options exchanges.

19. As explained above, changes in the prices of call and put options are driven primarily by changes in the prices of their underlying stocks. In addition, options prices depend upon their strike prices, the time remaining to expiration, the volatility of the underlying stock price,[10] the risk-free interest rate, and the expected amount and timing of any

[8] Most of Avalon's option trading took place on four exchanges, the NYSE American Options Exchange (AMEX), Chicago Board Options Exchange (CBOE), International Securities Exchange (ISE), and Options Market of NASDAQ PHLX (PHLX).

[9] Delayed Quotes for VMW, http://www.cboe.com/delayedquote/quote-table?ticker=VMW, accessed on March 14, 2018.

[10] The volatility is the standard deviation of the continuously compounded rate of return on the underlying stock.

dividends to be paid by the underlying stock prior to the expiration date of the options.[11,12] At the intraday time scales involved in the options trading in this case, changes in the interest rate and expected dividends are unlikely to have important impacts on options prices. Changes in volatilities are unlikely to have important impacts on the prices of the options traded in the Cross-Market Strategy because that strategy generally used in-the-money options, the prices of which are less sensitive to changes in volatilities than are those of other options.

20. Call options for which the underlying stock price exceeds the strike price are referred to as "in-the-money" because there would be a positive payoff if the call options were to be exercised immediately, while those for which the stock price is less than the strike price are "out-of-the-money." Put options for which the underlying stock price exceeds the strike price are termed "out-of-the-money" while those for which the stock price is less than the strike price are referred to as "in-the-money." Options for which the strike price is equal to the underlying stock price are "at-the-money." Generally, in-the-money options are more sensitive to changes in stock prices than are out-of-the-money options. Most of Avalon's option trading involved in-the-money options; the Cross-Market Strategy exploited the sensitivity of these

[11] More precisely, options prices depend on the expected amount and timing of dividends with ex-dividend dates prior to the expiration dates of the options. Options prices depend upon options strike prices because both the call and put options per-share exercise payoffs $S_T - K$ and $K - S_T$, and whether it is optimal to exercise an option, depend on the strike price. The volatility measures the dispersion of possible future stock prices; it affects current options prices because the dispersion of possible future stock prices affects the possible options payoffs. Similarly, the time remaining to expiration affects the dispersion of possible future stock prices and thus the possible options payoffs because large changes in stock prices are more likely the longer is the time remaining to an option's expiration. Expected dividend payments (and their timing) also affect future stock prices and thus options payoffs and prices, and the interest rate determines both the expected rate of growth of future stock prices (and thus future stock prices and option payoffs) and the discount rate used to discount the option payoff.

[12] See, for example, John C. Hull, <u>Options, Futures, and Other Derivatives</u> (9th ed.), Upper Saddle River, NJ: Pearson Education, Inc. (2015), Chapter 11, and John C. Cox and Mark Rubinstein, <u>Options Markets</u>, Englewood Cliffs, NJ: Prentice-Hall (1985), Chapter 2. Many of the properties of option prices were first derived in the seminal paper by Robert C. Merton (co-winner of the 1997 Nobel Prize in Economic Sciences) titled "Theory of Rational Option Pricing," <u>Bell Journal of Economics and Management Science</u> 4 (1973), pp. 141-183.

options to changes in underlying stock prices.

21. The relation between options prices and the underlying stock price has been thoroughly studied since the publication of the Black-Scholes-Merton formula in 1973 and the binomial options pricing model in 1979.[13] Since then there have been a great many academic papers extending the Black-Scholes-Merton analysis to develop related options pricing models, applying the Black-Scholes-Merton formula or related models to the options markets, and exploring the relationship between options prices and underlying stock prices. In such models options prices depend in part on underlying stock prices. Textbooks on options and other derivatives cover these models and the relationship between stock and options prices.[14] In addition, there is a significant body of academic literature discussing the information flow between the options and equity markets[15] and how hedging by options market makers impacts underlying stock prices.[16]

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[13] Fisher Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," Journal of Political Economy 81 (1973), pp. 637-654, Robert C. Merton, "Theory of Rational Option Pricing," Bell Journal of Economics and Management Science 4 (1973), pp. 141-183, and John C. Cox, Stephen A. Ross, and Mark Rubinstein, "Option Pricing: A Simplified Approach," Journal of Financial Economics 9 (1979), pp. 229-263.

[14] For example, John C. Hull, Options, Futures, and Other Derivatives (9th ed.), Upper Saddle River, NJ: Pearson Education, Inc. (2015) and Robert L. MacDonald, Derivatives Markets (3rd ed.), Upper Saddle River, NJ: Prentice-Hall (2013), John C. Cox and Mark Rubinstein, Options Markets, Englewood Cliffs, NJ: Prentice-Hall (1985), and Paul Wilmott, Derivatives: The Theory and Practice of Financial Engineering, New York: John Wiley & Sons (1998).

[15] For example, Sugato Chakravarty, Huseyin Gulen and Stewart Mayhew, "Informed Trading in Stock and Option Markets, Journal of Finance 59 (2004), pp. 1235-1257, Jun Pan and Allen M. Poteshman, "The Information in Option Volume for Future Stock Prices," Review of Financial Studies 19 (2006), pp. 871–908, Sophie X. Ni, Jun Pan and Allen M. Poteshman, "Volatility Information Trading In the Option Market," Journal of Finance 63 (2008), pp. 1059-1091, Dmitriy Muravyev, Neil D.Pearson, and John Paul Broussard, Is There Price Discovery in Equity Options?, Journal of Financial Economics 107 (2013), pp. 259-283, and Jianfeng Hu, "Does Option Trading Convey Stock Price Information," Journal of Financial Economics 111 (2014), pp. 625-645.

[16] For example, Sophie X. Ni, Neil D. Pearson, and Allen M. Poteshman, "Stock Price Clustering on Option Expiration Dates," Journal of Financial Economics 78 (2005), pp. 49-87, Jianfeng Hu, "Does Option Trading Convey Stock Price Information," Journal of Financial Economics 111 (2014), pp. 625-645, and Sophie X. Ni, Neil D. Pearson, Allen M. Poteshman, and Joshua White, "Does Option Trading Have a Pervasive Impact on Underlying Stock Prices?," working paper (2016).

22. Options pricing models that capture the relation between options prices, stock prices, and the other determinants of options prices are widely used by financial market participants. Among other uses, option pricing models are used by options market makers to determine the bid and ask prices they quote. They are also used by options market makers (and some other market participants) to determine the sensitivity of options prices to stock prices. This sensitivity is referred to as the option "delta."[17] The delta of an options position indicates the amount by which the value of the options position will change when the stock price changes by $1.[18] For example, if the delta of an options contract is 50 then the value of the options contract will increase or decrease by $50 if the stock price increases or decreases by $1, respectively. As a result, the options contract can be hedged by short-selling 50 shares of the underlying stock, because when the stock price changes the value of the short position will change by the same amount as the value of the options but in the opposite direction. If the delta of the options contract were negative 50 then the options contract could be hedged by buying 50 shares of the underlying stock, again because when the stock price changes, the value of the long stock position will change by the same amount as the value of the options contract but in the opposite direction. This practice of trading shares of stock to offset the delta of the options position is referred to as "delta hedging" the options position, and is a well-known, standard practice in the options markets, particularly by options market makers.[19]

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[17] See, for example, Chapter 19 of the textbook by John C. Hull, Options, Futures, and Other Derivatives (9th ed.), Upper Saddle River, NJ: Pearson Education, Inc. (2015) and Chapter 5 of Robert L. MacDonald, Derivatives Markets (3rd ed.), Upper Saddle River, NJ: Prentice Hall (2013).

[18] The relation is exact only for small stock price changes.

[19] See, for example, Chapter 13 "Market-Making and Delta-Hedging" in Robert L. MacDonald, Derivatives Markets (3rd ed.), Upper Saddle River, NJ: Prentice Hall (2013) and Nassim Taleb's well-known book Dynamic Hedging: Managing Vanilla and Exotic Options (New York: John Wiley & Sons, 1997). Sophie X. Ni, Neil D. Pearson, and Allen M. Poteshman, "Stock Price Clustering on Option Expiration Dates," Journal of Financial Economics 78 (2005), pp. 49-87 and Sophie X. Ni, Neil D. Pearson, Allen M. Poteshman, and Joshua

23. Options market makers are an important part of the options market because they provide liquidity to other market participants.[20] They quote bid and ask (offer) prices, and from time to time trade at their quoted prices, taking the opposite sides of the trades of other market participants. For example, on March 14, 2018 the Designated Primary Market-Maker (DPM)[21] who makes markets in the VMW options traded on the CBOE would ordinarily quote bid and ask prices for all of the 1020 VMW options that were available for trading on the CBOE on March 14, 2018. At any point in time typically there will not be public buy and sell orders for most of the 1020 VMW options, and if an investor wants to buy or sell one of them, the DPM or another option market maker will take the other side of the investor's trade. This is why the CBOE refers to options market makers as "the backbone of the Cboe's trading system."[22] In contrast to the equity markets, the options markets depend on market makers to provide liquidity.

24. Options market makers inevitably hold options positions due to their trading

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White, "Does Option Trading Have a Pervasive Impact on Underlying Stock Prices?," working paper (2016) show that delta-hedge trading by option market makers impacts stock prices. Sahn-Wook Huh, Hao Lin, and Antonio S. Mello, "Options Market Makers' Hedging and Informed Trading: Theory and Evidence," Journal of Financial Markets 23 (2015), pp. 26-58 and Jianfeng Hu, "Does Option Trading Convey Stock Price Information," Journal of Financial Economics 111 (2014), pp. 625-645 are examples of academic research papers that take it for granted that option market makers engage in delta-hedging. For example, Hu (p. 626) writes "a standard practice of the market makers is to perform delta hedging by trading on the underlying stocks."

[20] See, for example, Section 10.5 of John C. Hull, Options, Futures, and Other Derivatives (9th ed.), Upper Saddle River, NJ: Pearson Education (2015) and Chapter 13 of Robert L. MacDonald, Derivatives Markets (3rd ed.), Upper Saddle River, NJ: Prentice-Hall (2013). The CBOE describes option market makers as follows: "Market-makers are exchange members who provide liquidity in the marketplace by risking their own capital in making bids and offers for their own accounts in the absence of public buy or sell orders. They are the backbone of the Cboe's trading system." (http://www.cboe.com/education/getting-started/quick-facts/options-marketplace, accessed on January 26, 2018).

[21] "The DPM is a market-maker who is obligated to make continuous bid and ask prices in all option series in his appointed option classes. In return, the DPM is guaranteed certain rights to participate in each trade, either electronic or in open-outcry." (Options Quick Facts – Marketplace, http://www.cboe.com/education/getting-started/quick-facts/options-marketplace, accessed on March 14, 2018).

[22] Options Quick Facts – Marketplace, http://www.cboe.com/education/getting-started/quick-facts/options-marketplace, accessed on March 14, 2018.

activities in which they take the opposite sides of the trades of other market participants. This exposes them to the risk of stock price changes, because options prices depend on stock prices such that the values of options portfolios change when stock prices change. Options market makers often "delta-hedge" this risk as discussed above. Specifically, they often either buy or short sell stock to offset the delta of their options position. For example, if an option market maker's options position had a delta of 20,000 he or she might hedge it by short-selling 20,000 shares of the underlying stock, while if his or her options portfolio had a delta of negative 20,000 he or she might hedge it by buying 20,000 shares of the underlying stock. While options market makers do not always trade stock to hedge every change in the delta of their options position, they often execute hedge trades in the stock market following large options trades, because large options trades typically cause large changes in the deltas of their options position and therefore their market risk.

B. The Cross-Market Strategy

25. In the Cross-Market Strategy a trader executing the strategy first buys or sells stock to impact the stock price and cause the stock to trade at an artificial price level. This also causes options on the stock to trade at artificial levels, because quoted options prices are based on the underlying stock prices. The trader then trades options to establish an options position that will benefit when the underlying stock price and options prices return toward their previous levels. One can expect that the trader's purchase or sale of a large number of options will often cause market makers to hedge their positions by either buying or selling the underlying stock, which in the Cross-Market Strategy tends to cause the stock prices to return toward their previous levels. After establishing his options position, the trader begins liquidating his stock position, which further pushes the stock price toward its previous level. As the stock price

returns to its previous level, the trader's options position becomes more valuable, generally allowing the trader to close out the options position at a profit. After closing out his options position and any remaining stock position, his holdings of both the stock and related options return to zero. The trader typically loses money on the stock transactions, but he generally makes sufficient gains on the options transactions to more than make up for the stock losses. This relationship on average makes the Cross-Market Strategy profitable.

26. I will use a hypothetical example to describe the Cross-Market Strategy in more detail:

a. Assume that, prior to the execution of the Cross-Market Strategy, the stock targeted by this strategy is trading at $100 per share. The price, $100 per share, is the result of the natural interplay of supply and demand for the stock.

b. A trader then begins executing the Cross-Market Strategy by buying stock, and pushes the stock price up to an artificially high price of $100.50 per share.

c. Other than the trader executing the strategy, there is likely to be limited demand to buy the stock at this new price level— after all, the natural interplay of supply and demand prior to the buying by the trader resulted in a stock price of $100 per share.

d. The increase in the stock price causes call options prices to be artificially higher, and put options prices to be artificially lower.

e. For example, the increase in stock prices could cause the price of a one-month call option with a strike price of $90 to increase from $10.50 per share to an

artificial level of $10.95 per share.[23]

f. The opposite effect would apply to put options. For example, the increase in stock prices could cause the price of a one-month put with a strike price of $115 to decrease from $15.15 per share to an artificial level of $14.70 per share.

g. Thus, due to the trader's stock purchases, the prices of call and put options are different from the prices that would have prevailed based on the natural interplay of supply and demand. In other words, call options are at artificially higher prices and put options are at artificially lower prices as a result of the trader's stock trades.

h. After the trader successfully moves the stock price up in this manner, he or she will stop buying stock and cancel outstanding buy orders. At approximately the same time, the trader will purchase put options at the artificially low prices and/or sell call options at the artificially high prices. The options positions established by these trades are typically larger than the trader's previously established stock position.

i. Somewhat later, the trader will liquidate his stock position, and the market for the stock moves back toward its natural level.[24] Movements in the stock price back toward $100 will result in movements in the prices of corresponding options (e.g., call options will move back toward $10.50 and put options will

[23] An option contract is typically on 100 shares of stock, but option prices are quoted on a per-share basis. Thus, an option price of, for example, $10.50 per share corresponds to a contract value of 100 × $10.50 = $1,050.00.

[24] Options market makers on the other side of these options trades often sell stock to hedge their new option positions. This is an expected reaction in the options markets. When options market makers sell stock they are likely to find that there is limited demand for the stock at the artificial price of $100.50 per share because the trader has stopped buying stock (and cancelled his outstanding buy orders) and the previous natural interplay of supply and demand implied a stock price of $100 per share. As a result, the option market makers' hedge trades push stock prices down.

move back toward $15.15). As a result, the trader will be able to sell the put options for $15.15 per share, yielding a profit of $0.45 per share (less transaction costs).

j. Similarly, the trader can close any positions in the call options at $10.50 per share, yielding a profit of $0.45 per share (less transaction costs).[25]

27. In another version of the Cross-Market Strategy the trader begins by short-selling stock to drive the stock price down. This stock trading makes calls artificially cheaper and puts artificially more expensive. The trader stops selling stock, cancels his outstanding sell orders, and purchases calls (at artificially low prices) and/or sells puts (at artificially high prices), with options market makers typically taking the other side of the options trades. Options market makers likely buy stock to hedge their new options positions, and somewhat later the trader then buys stock to cover his short stock position. The combination of the trader's cancellation of his sell orders, options market makers' hedging trades, and the trader's covering of his short stock position causes stock prices to rise. The increase in stock prices in turn causes options prices to change in directions favorable to the trader, increasing the value of the options positions he holds. Finally, the trader sells the calls he previously purchased (at an artificially low price) and/or buys back the puts he previously sold (at an artificially high price) to close out his options positions at a profit.

28. The trader executing the Cross-Market Strategy typically suffers trading losses (negative trading revenue) on the stock trades, and expects to gain positive trading revenue on the options trades. Stock trading revenue is typically negative because during the trader's initial equity trades, the trader buys stock at artificially high prices or sells stock at artificially

[25] Given that an option contract typically covers 100 shares, the profit here would be $45.00 per options contract.

low prices as part of driving the stock price up or down. As stock prices return toward their natural lower (higher) levels, the trader sells (buys) stock, which contributes to the movement in the stock and corresponding options prices for the benefit of the trader's options position. In this process, the trader typically takes a loss on his stock trades. Because the stock trading revenue is negative, the options position will ordinarily be larger than the stock position so that the positive trading revenue on the options position will be large enough to more than offset the negative trading revenue on the stock position, such that the trader's overall trading revenue will be positive. This is an important part of the Cross-Market Strategy. If the options position were not typically large relative to the stock position then the Cross-Market Strategy would not be profitable. That said, the options position may not always be larger than the stock position because the trader may be unable to execute options trades of the desired size, or may not be able to execute them at favorable prices. As a result, the Cross-Market Strategy is profitable on average, but not necessarily in every instance of trading.

29. The stock trading by the trader executing the Cross-Market Strategy alters the stock and corresponding options prices by injecting false information about supply and demand into the market, so that the stock and corresponding options trade at artificial price levels.

30. The Cross-Market Strategy is a manipulative and deceptive practice because the trader's stock transactions are for the purpose of moving stock prices—and thus options prices—so that the trader can buy or sell options at artificially favorable prices. The strategy thus introduces false information about supply and demand into both the stock and options markets. The trader thereby uses stock transactions to manipulate the prices of the stock and options.

31. Below, I outline my methodologies for evaluating whether the Equity and Option Data contain patterns of trading consistent with the Cross-Market Strategy.

III. ANALYSIS AND OPINIONS

A. Summary Of Analysis

32. As described more completely below, I develop a set of criteria to analyze the Equity and Option Data and identify instances when trading was consistent with the Cross-Market Strategy, which I term "Cross-Market Loops."[26] I then conduct a series of further analyses to evaluate: (i) whether the traders' stock trading in the Cross-Market Loops were an important cause of the stock price movements during the crucial first part of the Cross-Market Loops; (ii) whether other characteristics of the Cross-Market Loops are consistent with using the stock trades to artificially impact the prices of stocks to benefit from trades in corresponding options; and (iii) to confirm that the results of my analysis are not sensitive to the numerical parameters I use in identifying the Cross-Market Loops.

33. I then compute the trading revenue derived from the Cross-Market Loops in the Equity and Option Data, and explain that the traders would have garnered much less trading revenue but for the stock price movements caused by their stock trading.

34. Finally, I explain why I believe that the Cross-Market Strategy does not have a legitimate economic rationale, and why the trading in the Cross-Market Loops is harmful to the market.

B. Identification Of Cross-Market Loops

1. Identification Of Loops

35. The Equity and Option Data is comprised of orders, cancellations, and

[26] NERA Economic Consulting ("NERA") assisted with the analyses in this report at my direction.

executions. The data also includes information indicating the trader that placed an order,[27] the exchange through which the order was routed, price,[28] symbol, quantity,[29] instruction,[30] date, and time.

36. The first step in my analysis is to identify ticker, date and trade group[31] combinations with orders and trades in both the stock and options, and no overnight positions. I define these instances as "Loops," where each Loop begins with a stock or option order and ends when all outstanding orders are closed through cancellation or execution. Loops are also required to have both stock and option orders or positions open at the same time.

37. Based on above criteria, I identify 796 Loops.[32] Below, I further examine these Loops to determine whether they fit the criteria for potential Cross-Market Loops.

2. Classification Of Loops

38. Based on my analysis of the data, I observe a certain degree of variability in traders' implementation of the Cross-Market Strategy. The simplest manner of implementation involved largely either initially purchasing or selling (but not both) a company's stock, along with an attempt to profit from corresponding options transactions (using either calls or puts). However, there were also instances in which traders used both purchases and sales of stock in implementing the Cross-Market Strategy. In addition, in some instances, traders purchased puts and/or sold calls, or purchased calls and/or sold puts. These patterns of transactions are all

[27] The Lime Equity and Option Data does not include a field for the trader and trade group.

[28] Price data includes the type of order placed, including limit orders, market orders, market on open orders, etc.

[29] The quantities in the Avalon Equity and Option Data include the quantity ordered, the quantity made visible to other market participants, the quantity cancelled, and the quantity executed.

[30] Instruction includes whether an order is a purchase, sale or cancellation order, and whether a trade is a purchase or sale execution.

[31] Trade groups are identified by the first three characters of the trader ID. For example, the trader 038_002S belongs to the 038 trade group.

[32] These Loops consist of 95% of Avalon's overall option trading volume.

consistent with the Cross-Market Strategy as they all involved using stock trades to favorably affect options prices. To facilitate my analysis, I establish certain categories of the Cross-Market Strategy, in order to calculate relevant statistics related to the execution and profitability of the strategy.

39. More specifically, I classify Loops as One-Directional Loops, Multi-Directional Loops, and Overshoot Loops as follows:

a. A Loop is deemed One-Directional if the stock position is either only long or only short, or the stock position is predominately long or short, meaning that the largest long (short) stock position is more than four times as large as the largest short (long) stock position.
b. A Loop is deemed Multi-Directional if the set of trades includes both long and short stock positions, and the largest long (short) stock position is less than or equal to four times as large as the largest short (long) stock position.
c. Overshoot Loops are the same as Multi-Directional Loops with respect to the stock position, but the trader only trades options in one direction, meaning that the options position consists of either purchased puts and/or sold calls, or purchased calls and/or sold puts.

3. Identification Of Cross-Market Loops

40. Next, I examine the trading patterns in the Loops to determine if they are consistent with the Cross-Market Strategy. This involves examining the nature and timing of the purchase or sale of options relative to the trading in the stock.

41. For each Loop, the maximum long or short equity position is termed the "Equity Peak." A One-Direction Loop is further termed "long" if the Equity Peak is a long position,

and "short" if the Equity Peak is a short position.

42. For the long One-Directional Loops, trading is consistent with the Cross-Market Strategy if there is either a purchase of puts and/or a sale of calls when the stock position is within 20% of the maximum long stock position. In addition, the options positions are predominately purchased puts and/or sold calls, meaning that the largest position in purchased puts and/or sold calls is more than four times as large as the largest position in sold puts and/or purchased calls. The patterns are consistent with the Cross-Market Strategy because the options trades to open the options position occur at a point when the puts are artificially cheaper and the calls are artificially more expensive as a result of the long stock purchases.

43. For the short One-Directional Loops, trading is consistent with the Cross-Market Strategy if there is either a purchase of calls and/or a sale of puts when the stock position is within 20% of the maximum short stock position. In addition, the options positions are predominately purchased calls and/or sold puts, meaning that the largest position in purchased calls and/or sold puts is more than four times as large as the largest position in sold calls and/or purchased puts. The patterns are consistent with the Cross-Market Strategy because the options trades to open the options position occur at a point when the calls are artificially cheaper and the puts are artificially more expensive as a result of the short stock sales.

44. For the Overshoot and Multi-Directional Loops, trading is consistent with the Cross-Market Strategy if the purchases of puts and/or sales of calls occur when the long stock position is within 20% of its maximum, and the sales of puts and/or purchases of calls occur when the short stock position is within 20% of its maximum. This pattern is consistent with the Cross-Market Strategy because put options are purchased and/or call options are sold at or near long Equity Peaks, so that the purchased puts are artificially cheaper and sold calls are at artificially higher price levels due to the impact of the equity trades on stock and option prices.

Similarly, call options are purchased and/or put options are sold near short Equity Peaks, so that the purchased call options are artificially cheaper and sold put options are at artificially higher price levels due to the impact of the equity trades on stock and options prices.

45. Using these steps, I identify 636 Loops within the Avalon Equity and Option Data that exhibit trading patterns consistent with the Cross-Market Strategy.[33] These consist of 497 One-Directional Loops, 36 Overshoot Loops, and 103 Multi-Directional Loops.[34] I define these Loops as "Cross-Market Loops." Exhibit 4 contains summary information about the Avalon Cross-Market Loops. Appendix A contains additional information about the Cross-Market Loops.

Exhibit 4. *Summary of Cross-Market Loops [Avalon/Lek]*

Appendix A. *List of Cross-Market Loops [Avalon/Lek]*

46. Although the Loops are divided into different groups, they share important characteristics. As the Cross-Market Loops are identified, put options are purchased and/or call options are sold at or near long Equity Peaks, so that the purchased puts and sold calls benefit from the impact of the stock trades on options prices. Similarly, call options are purchased and/or put options are sold near short Equity Peaks, so that the purchased puts and sold calls benefit from the impact of the stock trades on options prices. Exhibit 4 also shows that the Overshoot and Multi-Directional Loops share another key feature with the One-Directional Loops—the equity trades are on average unprofitable, and the call and put trades are on average profitable.

[33] As I explain below, adjusting the criteria for identifying Cross-Market Loops does not substantively affect my results.

[34] The results and analysis in this report focus on the Cross-Market Loops executed by trade group 038. Only seven of the Cross-Market Loops in the Avalon Equity and Option Data were not executed by trade group 038, and therefore I do not include those in this report.

C. Further Analyses

1. Stock Return Analysis

47. After identifying the Cross-Market Loops as described above, I carry out a number of tests to determine whether the stock price movements and returns during the Loops identified in the Avalon Trade and Option Data are consistent with the Cross-Market Strategy.[35]

48. I measure stock price movement by computing the stock returns during specified parts of the One-Directional and Overshoot Loops, such as from the beginning of the Loop ("Loop Start") to Equity Peak and from the time when Avalon begins liquidating its equity position ("Equity Liquidation") to the end of the Loop ("Loop End").[36] This analysis helps demonstrate that the trading is consistent with the Cross-Market Strategy because key features of the Cross-Market Strategy are that the trader's stock trading between Loop Start and Equity Peak impacts stock and option prices and causes the stock and options to trade at artificial levels. Later, between Equity Peak and Loop End, stock and option prices return, on average, to their pre-existing levels. Thus, we expect to see the Cross-Market Strategy affect stock returns during these specified parts of the Loops. Examining and drawing inferences from stock returns is a standard, well-accepted approach in the academic research literature.[37]

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[35] I carry out a similar analysis of the Lime Loops that I describe in Section III.F below.

[36] Because the Multi-Directional Loops include multiple equity peaks and equity positions are established and liquidated more than once, the specified periods are not defined for the Multi-Directional Loops. As a result, the Multi-Directional Loops are not included in this analysis.

[37] This approach is sometimes referred to using the terminology "event study" because originally it was used to study the valuation impacts of corporate events. The survey by Kothari and Warner (S.P. Kothari and Jerold B. Warner, "Econometrics of Event Studies," in B. Espen Eckbo (ed.), Handbook of Empirical Corporate Finance vol. 1, Amsterdam: North Holland (2007) indicates that the number of event studies published in a set of five top finance journals between 1974 and 2000 "easily exceeds 500," and "continues to grow" (p. 5). They write (p. 4) that there is "relatively little controversy about statistical properties of event study methods," and "short-horizon methods are quite reliable."

49. Exhibit 5 shows the average returns and market-adjusted returns (also referred to below collectively as returns) of the stocks during specified parts of the long and short One-Directional and Overshoot Loops, where the market-adjusted return is the difference between the stock return and the return of the SPDR S&P 500 exchange-traded fund (ETF) with ticker symbol SPY. I include market-adjusted returns in the analysis because they control for market-wide movements that may occur during the Loops which may also impact the stock returns, and therefore allow for more reliable inferences. Exhibit 5 also includes statistical tests of the hypotheses that the average returns during the specified parts of the Loops are different from zero. These statistical tests (results displayed as *p*-values) are a well-accepted and widely used method of determining the likelihood that the results occurred by chance.

Exhibit 5. Stock Return Analysis [Avalon/Lek]

50. The results of the Stock Return Analysis show that for the long Loops the average returns are positive from Loop Start to Equity Peak, negative from Equity Peak to Equity Liquidation, and negative from Equity Liquidation to Loop End. For the short Loops, average returns are negative from Loop Start to Equity Peak, positive from Equity Peak to Equity Liquidation, and positive from Equity Liquidation to Loop End. These average returns are consistent with the Cross-Market Strategy because they are consistent with the trader impacting stock prices (and therefore option prices) during the initial part of the Loop to contribute to the profitability of the option trades.

51. The statistical tests show that it is extremely unlikely—essentially impossible—that the average returns from Loop Start to Equity Peak occur by chance.[38] They also show

[38] The *p*-values reported in Exhibit 5 indicate that for the long Loops the probabilities of observing average returns and market-adjusted returns from Loop Start to Equity Peak of greater than or equal to those reported in Exhibit 5, assuming that the actual expected returns are zero, are 0.00% and 0.00%, respectively. For the short Loops

that it is essentially impossible that the average returns from Equity Peak to Equity Liquidation occurred by chance.[39] The returns from Equity Liquidation to Loop End on both the long and short Loops are also consistent with the Cross-Market Strategy because the average returns on the long and short Loops are negative and positive, respectively. Therefore, I conclude that returns during the specified parts of the Loops did not occur by chance but rather are compelling evidence that the stock price movements were consistent with the Cross-Market Strategy.

2. Trading Volume Analysis

52. I next examine whether Avalon's trading impacted the stock returns during the Loops.

a. Avalon's Trading As A Fraction Of Market Trading Volume During Specified Parts Of The Cross-Market Loops

53. To examine whether Avalon's trading impacted stock returns, I first calculate Avalon's share of trading volume during specified parts of the Loops. This analysis is relevant to determining whether Avalon's trading impacted the stock price movements because a trader's share of trading volume during the period when he is trading is well understood to be an important determinant of the impact of his trades on prices and returns.[40] Accordingly, if

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the probabilities of observing average returns and market-adjusted less than or equal to those reported in Exhibit 5, assuming that the actual expected returns are zero, are 0.00% and 0.00%, respectively.

[39] The *p*-values reported in Exhibit 5 indicate that for the long Loops the probabilities of observing average returns and market-adjusted returns from Equity Peak to Equity Liquidation less than or equal to those reported in Exhibit 5, assuming that the actual expected returns are zero, are 0.00% and 0.00%, respectively. For the short Loops the probabilities of observing average returns and market-adjusted returns greater than or equal to those reported in Exhibit 5, assuming that the actual expected returns are zero, are 0.00% and 0.00%, respectively.

[40] For example, in the well-known execution cost model due to Robert Almgren and Neil Chriss ("Optimal Execution of Portfolio Transactions," Journal of Risk 3, No 2 (Winter 2000), pp. 5-39) the temporary price impact of trading is related to fraction of market flow that the trading constitutes during the period when it takes place. This paper has been cited 1,114 times as of March 14, 2018. The existence of a relation between temporary price impact and the share of market volume during the interval is confirmed empirically (Robert Almgren, Chee Thum, Emmanuel Hauptmann, and Hong Li, "Equity market impact," Risk 18, No. 7 (July

Avalon's stock trading accounted for a large proportion of the total stock market trading volume during the relevant period of the Loops, that would be consistent with Avalon's trading impacting the stock price movements during that period. As discussed above, these stock price movements are an essential component of the Cross-Market Strategy.

54. Exhibit 6 shows that Avalon's stock trading volume accounted for a large fraction of total stock market trading volume during the period Loop Start to Equity Peak when Avalon was buying (short-selling) shares at the beginning of the long (short) Loops. During this period Avalon's trading accounted for almost half (48.4%) and slightly more than half (51.9%) of market trading volume during the long and short Loops, respectively.[41] Trading volumes of the magnitudes executed by Avalon were more than sufficient to impact stock prices.[42]

Exhibit 6. Trading Volume Analysis: Specified Parts of the Loops [Avalon/Lek]

b. Relation Between Avalon's Trading And Returns At The Beginning Of The Cross-Market Loops

55. I use regression analysis to estimate the relationship between Avalon's share of equity market trading volume and market adjusted returns from Loop Start to Equity Peak.[43]

2005), pp. 57–62. See also Robert Almgren's chapter in the Encyclopedia of Quantitative Finance ("Execution Costs," in Rama Cont (ed.), Encyclopedia of Quantitative Finance, Hoboken, NJ: John Wiley & Sons 2010).

[41] During the period Equity Liquidation to Loop End, Avalon's average share of stock market trading volume was also large, about one-quarter, though not as large as its share of stock market volume during the earlier periods because the liquidation periods are longer and thus included more trading by other market participants. This is consistent with the smaller returns observed during this period.

[42] Robert Almgren, Chee Thum, Emmanuel Hauptmann, and Hong Li, "Equity market impact," Risk 18, No. 7 (July 2005), pp. 57–62, and Robert Almgren, "Execution Costs," in Rama Cont (ed.), Encyclopedia of Quantitative Finance, Hoboken, NJ: John Wiley & Sons (2010). Almgren (2010) notes that "For trades that are a few percent of daily volume executed across several hours, the predicted impact costs are tens of basis points." This is consistent with my analysis of the price impacts caused by Avalon's trades.

[43] The regression equation is $r - r_{SPY} = a + b \times Share + \varepsilon$, where $r - r_{SPY}$ is the market-adjusted return on the underlying stock (that is, the difference between the stock return r and the return r_{SPY} on the S&P 500 ETF), *Share* is one of four measures of Avalon's share of trading volume from Loop Start to the Equity Peak, a and b

Regression analysis is a statistical technique that is widely used to estimate the relationship between one or more explanatory variables and a dependent variable to be explained. Exhibit 7 summarizes the results of my analysis. Specifically, the analysis shows that the magnitudes of the returns from Loop Start to Equity Peak are explained by the trader's share of market trading volume during the same period. Based on this analysis, I conclude that Avalon's trading between the Loop Start and the Equity Peak explained the price movements during this period.

Exhibit 7. Trading Volume Analysis: Regression Analysis of Market-Adjusted Returns From Loop Start to Equity Peak [Avalon/Lek]

c. Avalon's Trading During The Cross-Market Loops As A Fraction Of Daily Trading Volume

56. To further examine whether Avalon's stock trading (in particular, during the crucial initial part of the Loops) impacted the stock price movements, I consider whether Avalon's trading during the period from Loop Start to Equity Peak is a significant percentage of total daily trading volume. Exhibit 8 shows that on average, Avalon's trading during this part of the long (short) loops accounted for 2.93% (2.77%) of daily trading volume. These are larger than typical institutional trades,[44] and are larger than what would be necessary to impact

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are parameters to be estimated, and ε is the regression residual. For the long Loops, I first define *Share* to be the ratio of Avalon's trading volume between Loop Start and the Equity Peak to market trading volume during the same period. For the short Loops *Share* is defined to be the negative of the above quantity. Second, I alternatively define *Share* to be the ratio of Avalon's position at the Equity Peak to market trading volume between Loop Start and the Equity Peak, where a short position is treated as negative. This second measure captures only Avalon's net trading between the Loop Start and the Equity Peak. The third and fourth definitions of *Share* are similar to the first and second, except that the denominator of the ratios is daily market trading volume rather than market trading volume between Loop Start and the Equity Peak. The results in Exhibit 7 show that the estimated slope coefficient *b* is positive using all four measures of Avalon's share of trading volume. The tests of statistical significance (*p*-values) show that it is extremely unlikely that the positive relationship occurs by chance.

[44] For example, the descriptive statistics in Table 1 of Anand, Irvine, Puckett, and Venkataraman (Amber Anand, Paul Irvine, Andy Puckett, and Kumar Venkataraman "Performance of Institutional Trading Desks: An Analysis of Persistence in Trading Costs," Review of Financial Studies 25, No. 2 (2012), pp. 558-596) show that between 2003 and 2008 the average institutional trade (which is often broken up into smaller trades and executed over several days) was less than 2% of average daily trading volume on a single day. The descriptive statistics in Table I of Albert S. Kyle and Anna A. Obizhaeva ("Market Microstructure Invariance: Empirical Hypotheses," Econometrica 84, No. 4 (2016), pp. 1345-1404) shows that for most of the groups they consider

market prices.[45] Avalon's maximum long (short) stock position is an alternative measure of the magnitude of Avalon's trading. This measure of Avalon's trading, on average, represents 2.67% (2.54%) of total daily trading volume. These also are larger than typical institutional trades, and are more than sufficient to impact market prices.

Exhibit 8. Trading Volume Analysis: Trading Volume Compared to Daily Trading Volume [Avalon/Lek]

3. Analysis Of Other Possible Explanations For Avalon's Trading

57. I address the possible alternative hypothesis that the price movements were caused by news or other information that would have impacted stock and option prices even absent Avalon's trading. This analysis consists of two steps. First, I analyze whether the stock price returns reversed (i.e., returned toward their prior levels) during the Cross-Market Loops, which would be inconsistent with changes due to news or information. Second, I examine a randomly selected set of the Cross-Market Loops to see whether any news or information was reported about those Loops.

a. Return Reversals

58. A factor in assessing whether the stock price returns were caused by news or information is whether the stock price movements reversed themselves. It is well accepted in the academic research literature that price movements caused by the arrival of new information

the transactions they call "portfolio transitions," which are liquidations of entire institutional portfolios and typically take place over at least several days, averaged 2.62 percent of daily trading volume on a single day. The median size of a portfolio transition is less than or equal to 1.37% of average trading volume on a single day for all but the lowest-volume group of stocks.

[45] Robert Almgren, Chee Thum, Emmanuel Hauptmann, and Hong Li, "Equity Market Impact," Risk 18, No. 7 (July 2005), pp. 57–62, and Robert Almgren, "Execution Costs," in Rama Cont (ed.), Encyclopedia of Quantitative Finance, Hoboken, NJ: John Wiley & Sons (2010).

are long lasting or "permanent," that is, they are not quickly reversed.[46] The results in Exhibit 5 indicate that stock price movements during the Cross Market Loops did in fact reverse. Specifically, the returns from Loop Start to Loop End are negative (positive) for the long (short) Loops. This implies that the positive (negative) returns from Loop Start to Equity Peak on the long (short) Loops reversed completely (i.e., returned to or beyond their prior levels).

59. One can formally test the hypothesis that the returns from Loop Start to Equity Peak were not reversed by examining the returns from Equity Peak to Loop End. If the returns from Loop Start to Equity Peak were not reversed, then for both long and short Loops the returns from Equity Peak to Loop End should be zero. The results in Exhibit 5 show that the returns from Equity Peak to Loop End are highly unlikely to have occurred by chance.[47] Therefore, I reject the alternative hypothesis that Avalon's trading from the Loop Start to Equity Peak was due to news or information that would have impacted stock and option prices even absent Avalon's trading.

b. No News Events That May Have Influenced Trading During A Subset Of The Cross-Market Loops

60. To further evaluate whether the stock returns involved in the Cross-Market Loops can be explained by news or information in the market, I examine news reported in the market for a random sample of Cross-Market Loops.

61. The results are shown in Exhibit 9, which demonstrates that no news items

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[46] For example, in his Presidential Address (as President of the American Finance Association) Hans Stoll writes "Informational trading results in permanent price changes." (Hans R. Stoll, "Friction," Journal of Finance 55 No. 4 (2000), pp. 1479-2514.)

[47] For the long Loops, the probabilities of observing average returns and market-adjusted returns less than or equal to those in Exhibit 5 for the period from Equity Peak to Loop End, assuming that the actual expected returns are zero, are 0.00% and 0.00%, respectively. For the short Loops, the probabilities of observing average returns and market-adjusted returns greater than or equal to those in Exhibit 5 are 0.00% and 0.00%, respectively.

which may have influenced trading (referred to below as "informative news"), were reported on Dow Jones Factiva during the period from shortly before Loop Start to the Equity Peak for a random sample of the One-Directional Loops.

Exhibit 9. News Items in a Sample of One-Directional Loops [Avalon/Lek]

62. To construct Exhibit 9, I use a random number generator to randomly select a set of 20 One-Directional Loops. The stock tickers, dates, and key times of the selected Loops are shown in the first five columns of Exhibit 9. The sixth column indicates whether the Loops involved long or short equity positions. I then search on Dow Jones Factiva for news items on the date of the Loop. Within those news items, I then search for items with time-stamps indicating times during the period from five minutes before Loop Start through to the Equity Peak. I selected this period because if the trading from the Loop Start to Equity Peak was in reaction to news, the news must have been published either shortly before the Loop or during the first part of the Loop. Out of the 20 Loops, I found two Loops with a news item occurring during the period. For the PEP Loop on September 14, 2012, the news item contains a market recap that summarizes trading prices. For the KMB loop on October 14, 2017, the news item simply repeats an article that had previously been published. Neither of these publications would have influenced trading prices.

63. If the price movements between Loop Start and Equity Peak were caused by news in a significant fraction of the Cross-Market Loops, it is very unlikely that I would find that none of the random sample of 20 Cross-Market Loops included informative news items during the period I searched. For example, if the price movements in 50% of all of the Cross-Market Loops were caused by news, then the probability that none of 20 randomly selected Loops would have an informative news item is essentially zero. If the price movements in only

25% of the Cross-Market Loops were caused by news, then the probability that one observes zero with informative news items in 20 randomly selected Loops is only 0.32%. Given the results, this analysis of news items by itself implies that it is highly unlikely that the price movement in even as many as 25% of Avalon's Cross-Market Loops were caused by news. Combined with the previous results showing that the returns from Loop Start to Equity Peak were reversed, one can be highly confident that the pattern of price movements from Loop Start to Equity Peak was not caused by news.

4. Cancellation Analysis

64. Next, I examine Avalon's cancellations of outstanding orders to buy or sell stock during the One-Directional and Overshoot Loops at or near the Equity Peak, which is approximately the time that Avalon established its options positions. I also examine Avalon's outstanding order balance, defined as the total share size of stock orders that have not yet executed or cancelled. Exhibits 10 and 11 show that around the Equity Peak, the average number of equity order cancellations increased and the average equity order balance decreased to close to zero. This cancellation of stock orders is consistent with the Cross-Market Strategy because the trader's initial stock trades and orders are intended to move the stock price at an artificial level; once the stock reaches the Equity Peak, and the trader establishes his options position, the cancellation of the outstanding stock orders allows the stock price to return toward its pre-existing level. Thus, these results are consistent with Avalon's stock trades being for the purpose of artificially affecting stock and option prices and not due to any other legitimate economic rationale.

Exhibit 10. Cancellation Analysis: Order Cancellations [Avalon/Lek]

Exhibit 11. Cancellation Analysis: Order Balances [Avalon/Lek]

5. "But-For" Analysis

65. Because options prices depend on stock prices, Avalon's stock trading also impacted options prices. I now analyze and confirm whether Avalon's stock trading impacted options prices. I do this by estimating the trading revenue that Avalon would have garnered from 20 randomly selected Cross-Market Loops had it not traded stock to artificially alter the options prices; that is, I estimate what Avalon's trading revenue would have been "but-for" the impact of its equity trades on option prices. I measure this "but-for" options trading revenue by hypothesizing that Avalon's initial option trades placed near the Equity Peak occurred at the options prices prevailing immediately prior to the time when Avalon's stock trades impacted stock and options prices. Specifically, I assume that Avalon established its options positions at the NBBO options prices prevailing at the time of its first stock trade at the beginning of the Loop, just prior to when Avalon's stock trades began altering options prices. I do not change the prices at which Avalon exited its options positions. The "but-for" trading revenue for the 20 Loops totals a loss of $411,429, less than the actual trading revenue for these 20 Loops of $224,231.

66. I also carry out a second "but-for" analysis in which I assume that Avalon established its options positions at prevailing NBBO options prices at the beginning of the Loop, and also assume that Avalon closed out its options positions at the NBBO options prices prevailing at the time it began liquidating its equity position. Because these hypothetical options trades to establish and liquidate the options positions occur prior to Avalon's equity trades to establish and liquidate the equity positions, respectively, the hypothetical option trades do not benefit from the impact of Avalon's equity trading on equity and option prices. The "but-for" trading revenue for the 20 Loops in the second scenario totals a loss of $1,600,164, much less than the actual trading revenue of $224,231.

67. Exhibit 12 reports the results of the "but-for" analyses and shows that revenue is negative for the representative sample used to conduct these analyses. Statistical tests indicate that it is highly unlikely that the "but-for" total trading revenues for the sample of 20 Loops are negative by chance, i.e., it is highly unlikely that the full sample averages would not also be negative.[48] Therefore I conclude that the trading revenue of the Cross-Market Strategy would not have been positive "but-for" the fact that Avalon's equity trades impacted equity and option prices.

Exhibit 12. "But-For" Analysis [Avalon/Lek]

6. Sensitivity Analysis

68. I conduct sensitivity tests by varying the 20% cut-off used to identify Cross-Market Loops. At the current 20% cut-off, Loops are identified as Cross-Market Loops if option trades were executed at times when the equity position was within 20% of a long or short Equity Peak. Exhibit 13 shows that the number of Cross-Market Loops does not change significantly even when varying the cut-off from 0% to 100%.[49]

69. I also varied the ratio of long and short stock positions used to differentiate between One-Directional, Overshoot, and Multi-Directional Loops. At the current ratio of four times, the largest long (short) stock position has to be less than or equal to four times as large as the largest short (long) stock position for a Loop to be defined as a Multi-Directional Loop. Exhibit 14 shows that the number of Cross-Market Loops does not change significantly even when varying the ratio from one to ten. Therefore I conclude that the results are not sensitive

[48] The *p*-values reported in Exhibit 12 indicate that the probabilities that the negative "but for" total trading revenues occurred by chance are 0.00%.

[49] Exhibit 13 also shows that for 438 Cross-Market Loops, at least one set of options trades occurred when the stock position was at the Equity Peak.

to the exact cut-off or criteria used to identify Cross-Market Loops.

Exhibit 13. Sensitivity Analysis: Cut-Off Used to Identify Cross-Market Loops [Avalon/Lek]

Exhibit 14. Sensitivity Analysis: Cut-Off Used to Define Multi-Directional Loops [Avalon/Lek]

D. Examples Of Cross-Market Loops

1. One-Directional Loop In DECK On October 3, 2014

70. Avalon's trades in Deckers Outdoor Corporation stock (ticker symbol DECK) and put options on DECK on October 3, 2014 are an example of a long One-Directional Loop. Avalon began buying DECK stock at 12:56:23 p.m. when the DECK price (midpoint of the NBBO) was $94.35, and by 1:04:57 p.m. had accumulated a position of 32,549 shares.[50] Exhibit 15 shows how Avalon's stock position in DECK grew during this period, and also how it changed after it reached its peak at 1:04:57 p.m. During the period between 12:56:23 and 1:04:57 p.m. Avalon's stock purchases accounted for 69.5% of the stock trading volume in DECK and contributed to the 0.83% increase in NBBO price (NBBO midpoint) of DECK from $94.35 to $95.135. Exhibit 15 displays this increase in the DECK NBBO midpoint between 12:56:23 and 1:04:57 p.m., and also the price movement after 1:04:57 p.m.

Exhibit 15. Trading in DECK on October 3, 2014 [Avalon/Lek]

71. At about 1:04:57 p.m., just as Avalon's stock position reached its maximum of 32,549 shares and the DECK stock's NBBO price reached $95.135, Avalon purchased 931 DECK put options for a total of 93,100 shares.[51] Avalon's put position is also shown in

[50] The times in these examples, and therefore some of the market prices and percentages, are based on orders and executions. Thus, some of them would differ slightly if they were based on executions alone.

[51] These 931 put options were purchased between 1:04:57 and 1:04:58 p.m. and had strike prices of 94, 95, 96, 97, 97.5, 98, and 99. Between 12:56:49 and 1:04:57 p.m. Avalon had executed a number of purchase and sales of DECK put options, with each transaction consisting of only one contract. Prior to 1:04:57 p.m. Avalon's

Exhibit 15. Because the values of put options are negatively related to the stock price, Avalon's purchases of DECK stock between 12:56:23 and 1:04:57 p.m. caused the price of DECK stock to be artificially high and the price of DECK puts to be artificially low, permitting Avalon to purchase the puts at a favorable price. [52]

72. The price of DECK fell from $95.135 to $94.72 between 1:04:57 and 1:08:14 p.m., likely due to some combination of the tendency of stock prices that have been artificially altered to return to their previous level once they are no longer artificially inflated/depressed and delta-hedge trading by option market makers.

73. At 1:08:14 p.m., shortly after it purchased the puts, Avalon started selling shares to liquidate its long equity position, began selling more aggressively after about 1:23 p.m., and finished liquidating the position by 1:48:00 p.m. This change in Avalon's stock position is also shown in Exhibit 15. During this period Avalon's net sales of 32,549 DECK shares accounted for 25.5% of the total trading volume of 127,697 shares, and the price of DECK declined from $94.72 to $93.975, or by 0.79%.[53]

74. Avalon sold a total of 14 puts on a total of 1,400 shares between 1:11:17 and 1:18:05 p.m., shortly after it began liquidating its equity position. It then entered into 68 different trades in which it bought one put each at various times between 1:16:28 and 1:30:21 p.m., ending up with a position of 985 puts by 1:30:21 p.m.[54] It then liquidated its put position

largest purchased and sold options positions were 8 and 4 contracts, respectively. Avalon purchased and sold 20 puts for a loss of $200 prior to 1:04:57 p.m.

[52] For example, Avalon bought 99-strike Oct. 18 puts at $4.90, and later sold them at prices of $5.40, $5.80 and $5.90.

[53] Avalon's total trading volume in DECK during this period, including its purchases, accounted for 26.8% of market trading volume.

[54] These orders may have been placed to induce market makers to increase their bid and/or reduce their ask prices, respectively.

in two groups of trades at about 1:30:30 and 1:43:32 p.m., with both of the two sets of put trades occurring after Avalon had liquidated most of its equity position.

75. Avalon's put option trades earned positive trading revenues: It purchased 999 put contracts at an average price of $2.438 per share, and sold them at an average price of $2.987 per share, for an average trading revenue of $0.549 per share and total trading revenue of $54,840.[55] It garnered this positive trading revenue because the stock price decreased between the times when it purchased the puts and the later times when it sold them. Because option values change when underlying stock prices change, these stock price changes caused the changes in the put option prices. In contrast, Avalon's equity trades were unprofitable, yielding trading revenue of negative $29,707. Avalon's net revenue from this long One-Directional Cross-Market Loop was $24,933.

2. One-Directional Loop In VMW On November 26, 2012

76. Avalon's trades in VMware, Inc. stock (VMW) and call options on VMW on November 26, 2012 are an example of a short One-Directional Loop. The Loop started at 10:15:10 a.m. when Avalon started placing orders to short-sell VMW and the NBBO midpoint of VMW was $89.31. Avalon began short-selling VMW at 10:15:53 a.m. when the VMW price (midpoint of the NBBO) was $89.385, and by 10:25:12 a.m. had a short position of 73,647 shares. Exhibit 16 shows Avalon's accumulation of its short position in VMW during this period, and how Avalon's position changed after it reached its peak at 10:25:12 a.m. During the period between 10:15:10 and 10:25:12 a.m. Avalon's net sales of 73,647 shares accounted for approximately 55.6% of the trading volume in VMW and the price (NBBO

[55] Avalon also purchased and sold 20 put contracts prior to 1:04:57 p.m., and experienced a loss of $200 on these trades so that its overall profit on its option trades during the loop as $54,640.

midpoint) of VMW fell from $89.31 per share to $88.625, a return of negative 0.77%.[56] Exhibit 16 displays this decrease in the VMW price, and also the price movement after 10:25:12 a.m.

Exhibit 16. Trading in VMW on November 26, 2012 [Avalon/Lek]

77. Between 10:15:12 and 10:15:13 a.m., just as Avalon's short equity position reached its maximum of 73,647 shares and the VMW price reached $88.63, the trader purchased 2,864 VMW call options with strike prices of $85 and $87.5 on a total of 286,400 shares. This call position is also shown in Exhibit 16. Because the value of a call option is positively related to the stock price, Avalon's short sales of VMW stock between 10:15:10 and 10:25:12 a.m. that contributed to the decline in the VMW stock price also contributed to Avalon being able to purchase the calls at artificially low prices.

78. The price of VMW rose from $88.625 to $88.925 between 10:25:12 and 10:25:17 a.m., due to the combination of delta-hedge trading by option market makers and the natural reversion of the price once it was no longer artificially depressed.

79. At around 10:25:17 a.m., shortly after it purchased the calls, Avalon purchased a few hundred shares, and then began buying more aggressively to cover its short equity position at about 10:38 a.m. By 10:45:34 a.m. Avalon had covered its short equity position and established a long position of 2,665 shares. At this time and one second later at 10:45:35 a.m. it sold most of its call position, and then finished selling its calls around 10:46:22 a.m.[57] These

[56] While Avalon was generally shorting some shares during this period, at times it also purchased some shares of VMW. Its trading during this period, both long and short, accounted for 64.6% of the market trading volume of 132,443 shares between 10:15:10 and 10:25:12 a.m.

[57] Avalon actually sold one more call than necessary to liquidate the call position at 10:46:22 a.m. so at this time it briefly had a position of one sold call option. Avalon then covered the sold call position by buying a call at 10:46:43 a.m.

changes in Avalon's stock and call positions are also shown in Exhibit 16. Finally, Avalon liquidated its small long equity position by 10:46:46 a.m.

80. Avalon's call trades garnered positive trading revenue: it purchased 2,864 calls at an average price of $4.496 per share, sold 2,865 calls at an average price of $5.168 per share, and then purchased one call at a price of $4.40 per share, for options trading revenue of $192,790. This trading revenue can be largely attributed to Avalon's stock trading. Avalon's short selling of VMW stock contributed to artificially lowering VMW stock and call prices, permitting Avalon to purchased calls at beneficial prices. Then, during the period between 10:25:17 and 10:46:46 a.m. when Avalon was covering its short position, its net purchases of VMW shares to cover its short position and establish the small long position accounted for 23.7% of the total trading volume of 311,368 shares[58], and contributed to increasing the VMW price by 0.87% , from $88.925 to $89.70. Avalon's equity trading was not profitable, as it yielded trading revenue of negative $71,491. Avalon's net revenue from this Loop was $121,299.

3. Multi-Directional Loop In CL On August 15, 2012

81. Avalon's trades in Colgate-Palmolive Company stock (ticker symbol CL) and CL call and put options on August 15, 2012 are an example of a Multi-Directional Loop. Avalon began short-selling CL at 10:11:18 a.m. when the CL price (midpoint of the NBBO) was $105.965, and by 10:13:58 a.m. had accumulated a short position of 14,366 shares. Exhibit 17 shows the growth in Avalon's short position during this period, and also how Avalon's position changed after it reached its peak at 10:13:58 a.m. During the period between

[58] While Avalon was generally buying some shares during this period, at times it also sold some shares of VMW. Its trading during this period, both long and short, accounted for 27.3% of the market trading volume of 311,368 shares between 10:25:17 and 10:46:46 a.m.

10:11:18 and 10:13:58 a.m. the CL price (NBBO midpoint) fell from $105.965 per share to $105.845. Exhibit 17 displays this decrease in the CL stock price, and also the stock price movement after 10:13:58 a.m. During this period Avalon's trading accounted for 65.6% of the total market trading volume and contributed to decrease in the price of CL stock.

Exhibit 17. Trading in CL on August 15, 2012 [Avalon/Lek]

82. At 10:13:58 a.m., just as Avalon's short stock position reached its maximum size of 14,366 shares, Avalon purchased 900 CL call options on a total of 990,000 shares of CL stock at a call price of $6.4 per share – an artificially low price resulting from Avalon's equity trading. The CL stock price then increased from $105.845 to $105.965 at 10:14:25, likely due to market maker buying of stock to delta-hedge the sold call positions they obtained by taking the opposite side of Avalon's call purchases. At 10:14:25 a.m., Avalon began buying CL stock, covered its short position, and continued buying to establish a long position. By 10:18:47 a.m. Avalon had established a long position of approximately 28,710 shares, at which point the CL stock price was $106.52 per share, the highest level it achieved during the Loop. Between 10:14:25 and 10:18:47 a.m. Avalon accounted for 48.7% of stock trading volume. After driving up the stock price, Avalon sold the 900 calls at an average price of $6.669 per share. Avalon then sold 2,376 shares of CL stock between 10:19:04 and 10:20:22 a.m.

83. Shortly thereafter, at 10:22:49 a.m. when the CL stock price was $106.205, Avalon resumed buying CL stock. By 10:23:58 a.m. Avalon had a long position of 31,991 shares, at which point the CL stock price was $106.41 per share. The increase in the stock price from $106.205 at 10:22:49 a.m. to $106.41 at 10:23:58 a.m. was likely due to Avalon's buying—Avalon accounted for 68.9% of stock market trading volume. The increase in the CL stock price due to Avalon's buying also caused put option prices to be artificially lower

because put option prices are negatively related to their underlying stock prices. At 10:23:58 a.m., just as the stock price reached $106.41 per share, Avalon purchased 288 put options with a strike price of 110 on a total of 28,800 shares of stock at a price of $4 per share, benefitting from the lower put option prices it had caused through its CL stock purchases.

84. The CL stock price declined immediately after 10:23:58 a.m., likely caused by option market maker delta hedging and Avalon's sale of 4,334 CL shares between 10:24:27 and 10:24:52 a.m. After 10:24:52 a.m. the CL price slowly drifted down, and Avalon resumed selling stock at about 10:51:11 a.m., brought its stock position down to zero and then continued (short) selling, establishing a short position of 4,875 shares by 11:00:09 a.m. Just before that, at 11:00:08 a.m., it sold 300 puts (the 288 it purchased at 10:23:58 a.m. plus 12 more) on a total of 30,000 shares at a price of $4.65 per share, and then finally brought its stock position back to zero and bought back the 12 puts at 11:01:05 a.m. at a put price of $4.75 per share, closing out its options position.

85. Avalon's put transactions during this Cross-Market Loop yielded positive trading revenue, as Avalon bought the puts at an average price of $4.03 per share and sold them at price of $4.65 per share, for a total trading revenue of $18,600. Avalon's equity trading was not profitable, as it yielded trading revenue of negative $25,296. Avalon's net revenues from this Multi-Directional Loop, including its losses on its stock trades, and gains on its transactions in both calls and puts, was $17,539.

E. Trading Revenues

86. Exhibit 18 reports the total trading revenue from the Avalon Cross-Market Loops. For each set of Cross-Market Loops, the exhibit reports the trading revenue of the equity trades, the trading revenue of the option trades, and the combined trading revenue of the

equity and option trades. Trading revenue is computed as the difference between the amounts received (price × quantity) for securities sold less the amounts paid for securities purchased, except in the 12 Avalon Cross-Market Loops during which options were exercised. When options are exercised, the stock is treated as having been acquired or sold at the NBBO midpoint at the time of option exercise, and the difference between the option strike price and the equity NBBO midpoint (multiplied by the quantity of shares acquired or sold via the option exercise) is included as part of the option trading revenue.

Exhibit 18. Trading Revenue: Cross-Market Loops [Avalon/Lek]

87. Exhibit 18 shows that Avalon typically experienced losses (negative trading revenue) on the equity trades, and garnered positive trading revenue on the options trades. Options trading revenue was large enough to more than offset the negative equity trading revenue, so that for each group of Loops the total combined trading revenue is positive. Avalon's trading revenue on the Cross-Market Loops (involving trading through Lek) totaled $7,703,166.

F. Analyses of Cross-Market Loops Executed Through Lime

88. Exhibits 19 – 25 repeat the analyses in Exhibits 4 – 6, 8, 10, 11 and 18, but for the Cross-Market Loops executed through Lime. The results in Exhibits 19 – 25 are consistent with the results from the analyses of the Avalon Cross-Market Loops. In the Lime Equity and Option Data, I identify 32 Loops that exhibit trading patterns consistent with the Cross-Market Strategy. This includes 25 One-Directional Loops, 3 Overshoot Loops, and 4 Multi-Directional Loops.

a. ***Summary Information.*** Exhibit 19 contains summary information for these Loops. Appendix B contains additional information about these Cross-Market

Loops.

b. ***Stock Return Analysis***. Exhibit 20 shows that the stock returns during the specified periods are consistent with the Cross-Market Strategy.

c. ***Trading Volume Analysis: Specified Parts of the Loops.*** Exhibit 21 shows that trading through Lime from Loop Start to Equity Peak is a large fraction of total market volume during the same period.

d. ***Trading Volume Analysis: Trading Volume Compared to Daily Trading Volume.*** Exhibit 22 shows that trading through Lime between Loop Start and Equity Peak is a significant fraction of daily trading volume.

e. ***Cancellation Analysis: Order Cancellations.*** Exhibit 23 shows that cancellation of outstanding equity orders increases at or near the Equity Peak.

f. ***Cancellation Analysis: Order Balances.*** Exhibit 24 shows that the outstanding order balances at or near the Equity Peak decreased to close to zero.

g. ***Trading Revenues Through Lime.*** Exhibit 25 shows that the trading revenues on the Cross-Market Loops executed through Lime totaled $450,799.

Therefore, the results for the Lime Loops are also consistent with the Cross-Market Strategy.

Exhibit 19. *Summary of Cross-Market Loops [Lime]*

Exhibit 20. *Stock Return Analysis [Lime]*

Exhibit 21. *Trading Volume Analysis: Specified Parts of the Loops [Lime]*

Exhibit 22. *Trading Volume Analysis: Trading Volume Compared to Daily Trading Volume [Lime]*

Exhibit 23. *Cancellation Analysis: Order Cancellations [Lime]*

Exhibit 24. *Cancellation Analysis: Order Balances [Lime]*

Exhibit 25. *Trading Revenue: Cross-Market Loops [Lime]*

Appendix B. *List of Cross-Market Loops [Lime]*

H. No Legitimate Economic Rationale For The Cross-Market Strategy

89. I find that there is no legitimate economic rationale for the Cross-Market Strategy because it is profitable only due to the trader's ability to establish the options positions at artificial prices, which are caused by the trader's own stock trading.

90. The analyses above support this finding. On average, stock prices at the end of the Cross-Market Loops are close to their levels at the beginning. Because option values and quoted option prices are based on stock prices, this also implies that option prices at the end of the Cross-Market Loops are similar to option prices at the beginning. Therefore, the strategy was profitable only because the traders benefited from entering and exiting options positions at artificial prices during the Cross-Market Loops. The "But For" Analysis supports this conclusion.

91. The traders caused these artificial option prices via stock trading. This is shown through the Trading Volume Analysis, which found that stock trading within the Cross-Market Loops accounted for approximately 50% of stock market trading volume during the first part of the Cross-Market Strategy and more than 2.5% of daily trading volume, and the regression analysis showing that Avalon's trading explains returns during the first part of the Cross-Market Strategy. The Analysis of Possible Other Explanations, which demonstrated that prices reversed themselves during the Cross-Market Loops and that there were no informative news releases during the key periods for a selection of the Cross-Market Loops, also support this finding. These analyses show that the traders were using their stock trades to cause artificial price movements in the stocks and options during the Cross-Market Loops for the purpose of

benefiting their options trades, and not for any other legitimate economic reason.

92. To further support the conclusion that there is no legitimate economic rationale for the Cross-Market Strategy, I consider and rule out three other possible reasons for the trades executed under the Cross-Market Strategy.

1. Consideration Of Whether The Cross-Market Strategy Is Primarily A Stock Trading Strategy

93. I next consider whether the Cross-Market Strategy is primarily a stock trading strategy, with the options being used to hedge the stock trades. This possibility is ruled out by the fact that the stock trades, considered in isolation, are not profitable in general.[59] Were the Cross-Market Strategy primarily a stock trading strategy with the options being used to hedge the stock positions one would expect to see that the stock trades were, on average, profitable and the option trades were, on average, unprofitable. In addition, the option positions were not sized to hedge the stock positions, but rather were larger than the stock positions. In fact, as pointed out above the Cross-Market Strategy is profitable only if the options positions taken by Avalon during the Cross-Market Loops are large relative to the stock positions.

2. Consideration Of Whether The Cross-Market Strategy Is Primarily An Options Trading Strategy

94. I also consider whether the Cross-Market Strategy is primarily an options trading strategy, and that the stock positions were intended to hedge the options positions in a practice known as delta hedging. This is not the case, however, because Avalon's stock trades

[59] It is essentially impossible that the equity trading revenues were negative simply by chance. Of the 636 Avalon Cross-Market Loops, equity trading revenue was negative for 593 Loops. The probability that this could happen by chance is almost zero. Specifically, if one assumes that on each Loop positive and negative trading revenue were equally likely, the expected number of loops with negative equity trading revenue is 50% × 636 = 318. The probability that equity trading revenue would be negative on 593 or more loops out of 636 can be computed using the binomial distribution and is 5.18×10^{-125}.

were executed prior to the options trades, that is, before Avalon knew the sizes of the options positions it would be able to establish. Second, the Cross-Market Strategy can only be a profitable delta-hedged options strategy if the option trading was carried out in anticipation of changes in some other factor that determines option prices, namely changes in option implied volatilities.[60] But this cannot be the motivation behind the Cross-Market Strategy, as Avalon generally traded in-the-money options which have limited exposure to changes in option implied volatilities. In addition, the possibility that the Cross-Market Strategy may be a delta-hedged options strategy executed in anticipation of changes in options implied volatilities is inconsistent with the explanations of the strategy provided in testimony by defense witnesses, which I consider next.

3. Consideration Of Whether The Initial Stock Trades Were For The Purpose Of Learning About The Liquidity Of The Stock Market

95. Defense witnesses characterized the Cross-Market Strategy as "liquidity arbitrage"[61] and testified that Avalon's initial equity trades at the beginning of the Cross-Market Loops were for the purpose of learning about the liquidity of the stock market.[62] The witnesses apparently would have one believe that this characterization of the Cross-Market

[60] Option prices also depend on interest rates and (expectations of) future dividends and their timing. But it is implausible that option trades that were typically left open for one or a few hours were executed in anticipation of changes in interest rates and/or dividends.

[61] For example, SEC Testimony of Sergey Pustelnik, 2/11/2014, p. 222-224 (related testimony is at pp. 245-247, 254-255, and 261-264), SEC Testimony of Samuel Lek, 11/15/2013, pp. 208-211, and SEC Testimony of Nicolas Louis, 10/22/2013, pp. 156-157, 170. The use of the term "liquidity arbitrage" by the defense witnesses differs from the standard usage of this term. Ordinarily liquidity arbitrage refers to strategies that involve buying and holding illiquid assets that trade at a discount as compared to otherwise similar liquid assets (and thus have higher expected returns), and selling the otherwise similar liquid assets. Sometimes this takes the form of setting up a special purpose vehicle that buys a pool of illiquid assets, for example bank loans, and issues claims against them, for example collateralized loan obligations.

[62] For example, Sergey Pustelnik testified that the purpose of the stock trades was "to find out what the actual liquidity is in that stock" and "to try to find out the real liquidity" (SEC Testimony of Sergey Pustelnik, 2/11/2014, pp. 265, 268). Samuel Lek testified that the "stock part of this transaction is a method of discovering actual liquidity" and that "I want to reiterate that the stock leg of this transaction is not any more than a method of measuring liquidity in the stock" (SEC Testimony of Samuel Lek, 11/15/2013, pp. 211, 212).

Strategy implies that the initial stock trades were not intended to impact the stock and option prices. I consider this claim, but reject it for several reasons.

96. First, the claim that the initial stock trades were only intended to discover the liquidity of the stock market is inconsistent with the trades that were executed. As shown in Exhibits 5 – 8 and 20 – 22, the stock trades had important impacts on stock prices and were a significant fraction of trading volume. It is difficult to credit the claim that such high volumes of stock trading that had significant impacts on stock prices were intended simply to learn about stock market liquidity. As discussed in section III.C.2, the trades were larger than typical institutional trades, and were large enough to significantly impact stock prices. They were much larger than was necessary to test liquidity.

97. Second, in the long Cross-Market Loops in which the trader initially purchased stock, the trader profited from subsequent declines in the stock price as market makers sold stock to hedge their options positions and the trader liquidated his stock position. This occurred because the stock price declines caused changes in options prices favorable to the trader. In the short Loops in which the trader sold stock at the beginning, the trader profited from subsequent increases in the stock price as market makers bought stock to hedge their options positions and the trader bought stock to cover his previously established short stock position. This is because the stock price increases caused favorable changes in option prices. The defense witnesses would have one believe that Avalon *bought* stock in large quantities to test how the stock market would respond to option market makers' *selling* of stock, and *sold* stock in large quantities to test how the stock market would respond to option market makers' *buying* of stock. This is not credible, because buying stock (which tends to, and in fact did push the stock price up) is not the best or most natural way to discover how the stock market

would respond to sales by option market makers. The best way to discovery how the market would respond to sales is by selling stock. Similarly, selling stock is not the best or most natural way to discovery how the market would respond to purchases by options market makers. Buying or selling stock is, however, the best way to increase or decrease the price of the stock.

98. Rather, the initial stock trades artificially altered stock prices and thereby created the situation in which the stock market would respond to the stock trades that options market makers executed to hedge their options positions. For example, in the long loops, the trader stopped buying stock at the Equity Peak, cancelled his outstanding buy orders, and at approximately the same time, bought put options and/or sold call options. Options market makers then typically sold shares to hedge their new option positions. The options market makers would have found that there was limited demand for the stock at the artificial price level not because the trader learned about liquidity and found it lacking and then chose to execute the Cross-Market Strategy at that time, but rather because the trader *created* the situation of limited liquidity at the artificial stock price level by artificially raising the stock price above the level implied by the natural interplay of supply and demand, and then cancelling the buy orders that pushed up the stock price. As I indicate above there is no legitimate economic rationale to this trading, because the trading is profitable only because the trader is able to trade options at artificial price levels created by the stock trading.

99. Based on this analysis and discussion, I conclude that the Cross-Market Strategy did not have a legitimate economic rationale related to learning about the liquidity of the stock. The fact that Avalon's trading from the Loop Start to the Equity Peak represents a significant fraction of both Loop and daily trading volume renders implausible any claim that Avalon's

equity trading during that period was for the purpose of learning about stock market liquidity.

IV. HARM TO MARKET AND MARKET PARTICIPANTS

A. Market Participants Executed Equity And Option Trades At Unfavorable Prices

100. During the periods when the Cross-Market Strategy was being executed, other stock and option market participants traded both with the traders executing the Cross-Market Strategy and with each other. Because the Cross-Market Strategy caused stock and option prices to move to artificial levels, it impacted the prices at which other market participants bought or sold the stocks in which the traders were carrying out the Cross-Market Strategy. It also impacted the prices of any trades in the stocks' corresponding options.[63] Specifically, any other market participants who purchased the affected stocks or their corresponding options during periods in which the Cross-Market Strategy trading caused the stock or option prices to be artificially high paid more than they would have paid in the absence of the Cross-Market Strategy trading, while any other market participants who sold the affected stocks or their corresponding options during periods in which the trading caused the stock or option prices to be artificially low received less than they otherwise would have received in the absence of the Cross-Market Strategy. The fact that the Cross-Market Strategy caused some market participants to either pay more or receive less than they otherwise would have paid or received obviously caused them harm.[64]

[63] Because option values and quoted option prices are based on stock prices and the Cross-Market Strategy stock trading altered stock prices, the stock trading impacted the prices of all options based on the stocks in which the traders executed the Cross-Market strategy, even if the traders executing the Cross-Market Strategy never traded in those options.

[64] It is likely that some market participants benefited from the manipulation by selling stock or options when prices were artificially high or by buying when prices were artificially low. The likelihood that some participants benefited does not alter the fact that others were damaged, and does not alter the fact that the manipulation of prices is harmful to the market overall.

B. Decrease In Option Market Quality

101. It is likely that the Cross-Market Strategy also had an ongoing impact on the prices and quantities that option market makers were willing to quote, by causing them to quote either lower bid prices and/or higher ask prices (that is, a wider bid-ask spread), smaller quantities, or both. A wider bid-ask spread would have harmed all other market participants, requiring them to buy options at the higher ask prices and/or sell them at the lower bid prices. Wider bid-ask spreads may also discourage some investors from participating in the market. The impact on the quantities that option market makers were willing to quote would have also harmed other market participants as it reduced the quantities of options available for them to buy or sell.[65]

102. It is almost certain that the bulk of the trade counterparties of the Cross-Market Strategy traders were option market makers, who suffered losses on their trades with the Cross-Market Strategy traders. In the terminology used in academic research literature, the option market makers suffered from adverse selection, which means that they experienced losses from trading with another market participant who had superior information about market prices. In this case, the traders executing the Cross-Market Strategy knew that the options prices were at artificial levels due to their stock trading artificially impacting stock prices.

103. The concept of adverse selection is well established and widely accepted in the academic research literature.[66] Adverse selection is one of the important determinants of

[65] The ability to trade large size (large quantities of securities) is one of the important dimensions of market liquidity (see, for example, Larry Harris, Market Microstructure for Practitioners, Oxford: Oxford University Press (2003), Chapter 19).

[66] See, for example, Bruno Bias, Larry Glosten, and Chester Spatt, "Market Microstructure: A Survey of Microfoundations, Empirical Results, and Policy Implications," Journal of Financial Markets 8 (2005), pp. 217–264.

market liquidity, as market makers and other liquidity providers who know that they will suffer losses to market participants with superior information will quote wider bid-ask spreads to enable them to earn profits that are large enough to offset their losses from trading with market participants who have superior information.[67] Option market makers may have also responded by quoting smaller quantities of options for purchase or sale.

104. The negative impacts on the option market, namely the wider bid-ask spreads and smaller quantities available at the NBBO, would not be not restricted to the periods during which the traders were executing the Cross-Market Strategy. Once option market makers became aware of the Cross-Market Strategy, they would understand that they were exposed to the risk that the strategy might be executed at any time. As a result, they would quote wider spreads and/or smaller quantities throughout the trading day. Options market makers would also be likely to quote wider spreads and smaller quantities in other options, not just those previously targeted by traders employing the Cross-Market Strategy.

V. CONCLUSIONS

105. Based on these analyses, and on my knowledge of and experience with the financial markets, I have formed the following opinions:

a. Using the Avalon Equity and Option Data, I identified 636 instances of trading in stock and corresponding options that are consistent with the Cross-Market Strategy.

b. Avalon's stock trading during these loops of the Cross-Market Strategy impacted the prices of the stock and corresponding options in a way that led

[67] See, for example, Larry Harris, Market Microstructure for Practitioners, Oxford: Oxford University Press (2003), Chapter 14.

to increased profits from Avalon's trades.

c. The amount of trading revenue attributable to Avalon's trading through Lek identified as consistent with a Cross-Market Strategy was $7,703,166.

d. Using the Lime Equity and Option Data, I identified 32 instances of trading in stock and corresponding options that are consistent with the Cross-Market Strategy.

e. The amount of trading revenue attributable to the trading through Lime identified as consistent with a Cross-Market Strategy was $450,799.

f. There does not appear to be a legitimate economic rationale for the trading activity that I identify as consistent with the Cross-Market Strategy.

g. The Cross-Market Strategy is manipulative and deceptive, and harmful to the securities markets and market participants.

106. My work in this matter is ongoing, and I reserve the right to supplement this analysis in the future.

Neil D Pearson

NEIL D. PEARSON, PH.D.

Dated: March 16, 2018